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H4P PDCSL
H4M MA

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GB 2282300 A GB 2278260 A

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ONLINE : WPI

(54) Abstract Title
Communication system and method

(57) An orthogonal code hopping multiple access communication system divides channels according to the hopping patterns of the orthogonal codes allotted to the respective channels. The communication system includes a transmitter for modulating input digital signals in an orthogonal code hopping multiple access technique and transmitting the modulated digital signals, and a receiver for receiving the digital signals in the orthogonal code hopping multiple access technique and restoring the digital signals. As shown digital signals D are encrypted by mixing 11 with respective hoping codes OC, combined 12 and mixed 14 with a PN sequence to provide a more uniform power spectral density before transmission 17.

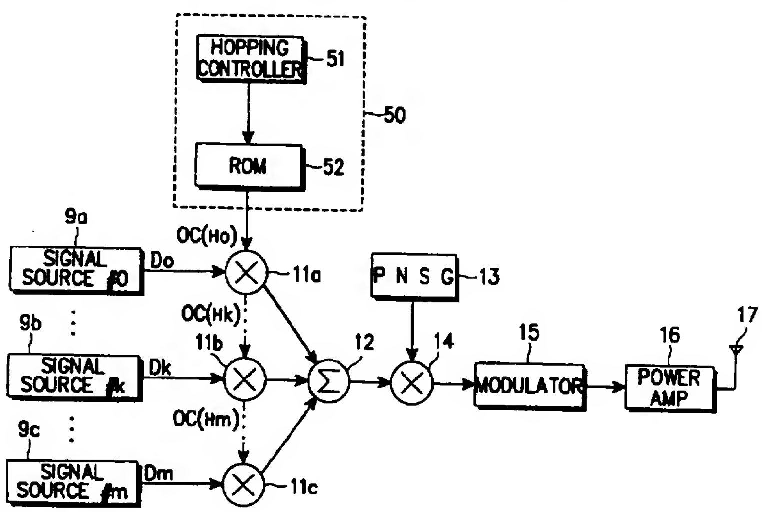

FIG. 3A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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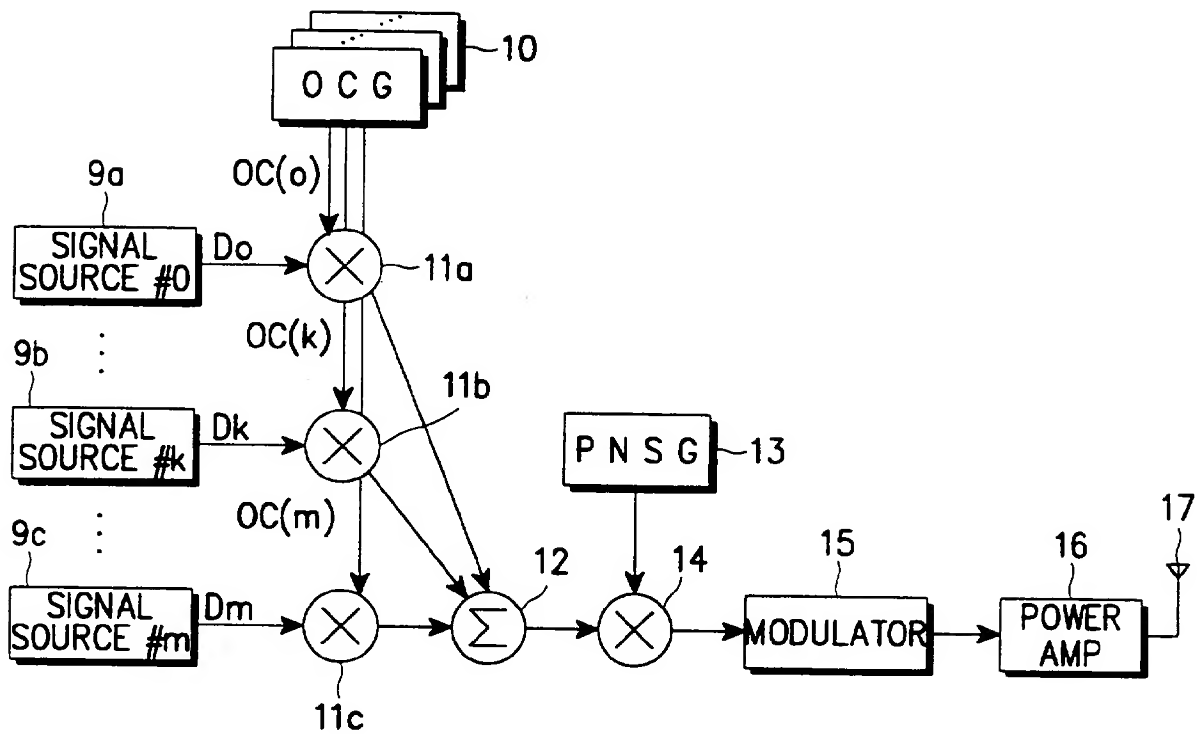
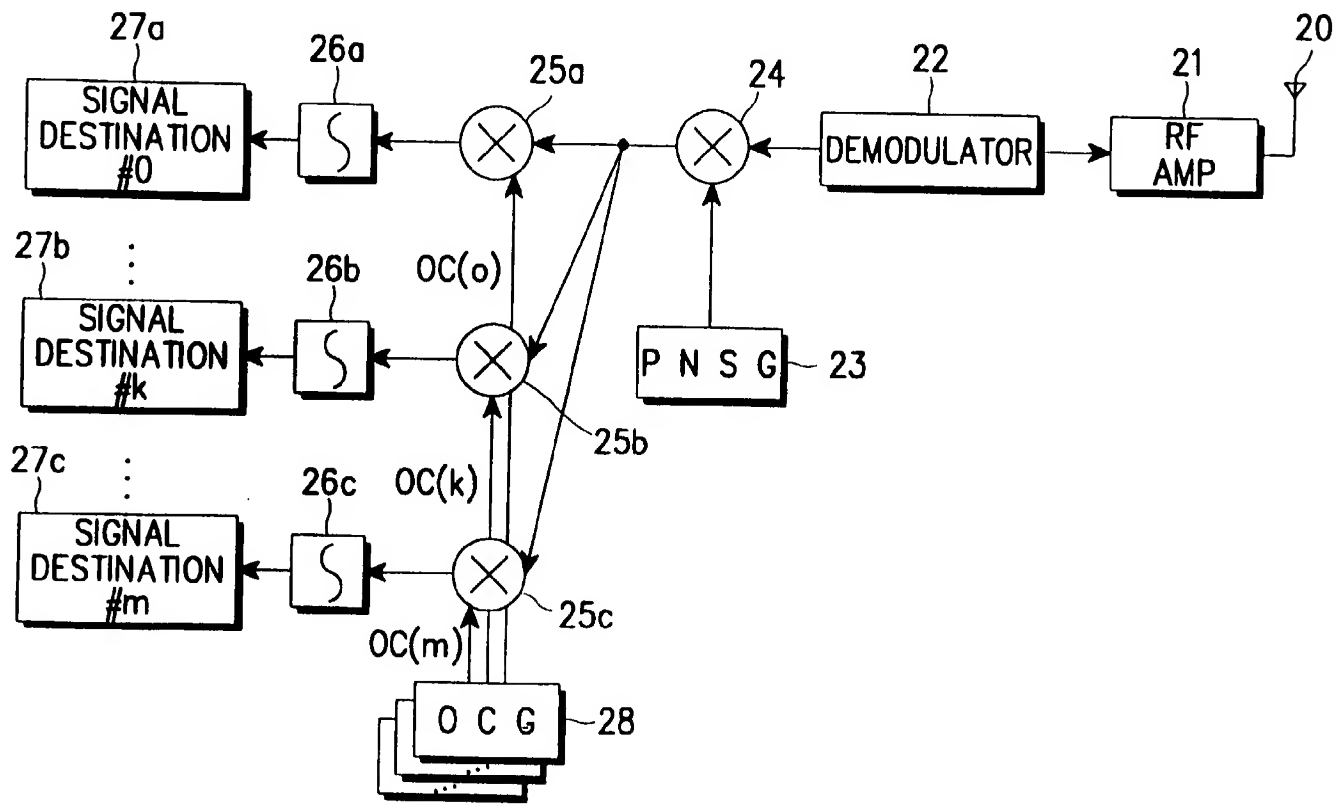

OCG
10
OC(o)
9a
SIGNAL SOURCE #0
Do
11a
9b
OC(k)
11b
SIGNAL SOURCE #k
Dk
PNSG
13
9c
OC(m)
17
12
14
15
16
SIGNAL SOURCE #m
Dm
MODULATOR
POWER AMP
11c

FIG. 1A



20
21
RF
AMP
22
DEMODULATOR
24
PNSG
23
25a
25b
25c
OC(o)
OC(k)
OC(m)
OCG
28
26a
26b
26c
27a
SIGNAL
DESTINATION
#0
27b
SIGNAL
DESTINATION
#k
27c
SIGNAL
DESTINATION
#m

FIG. 1B

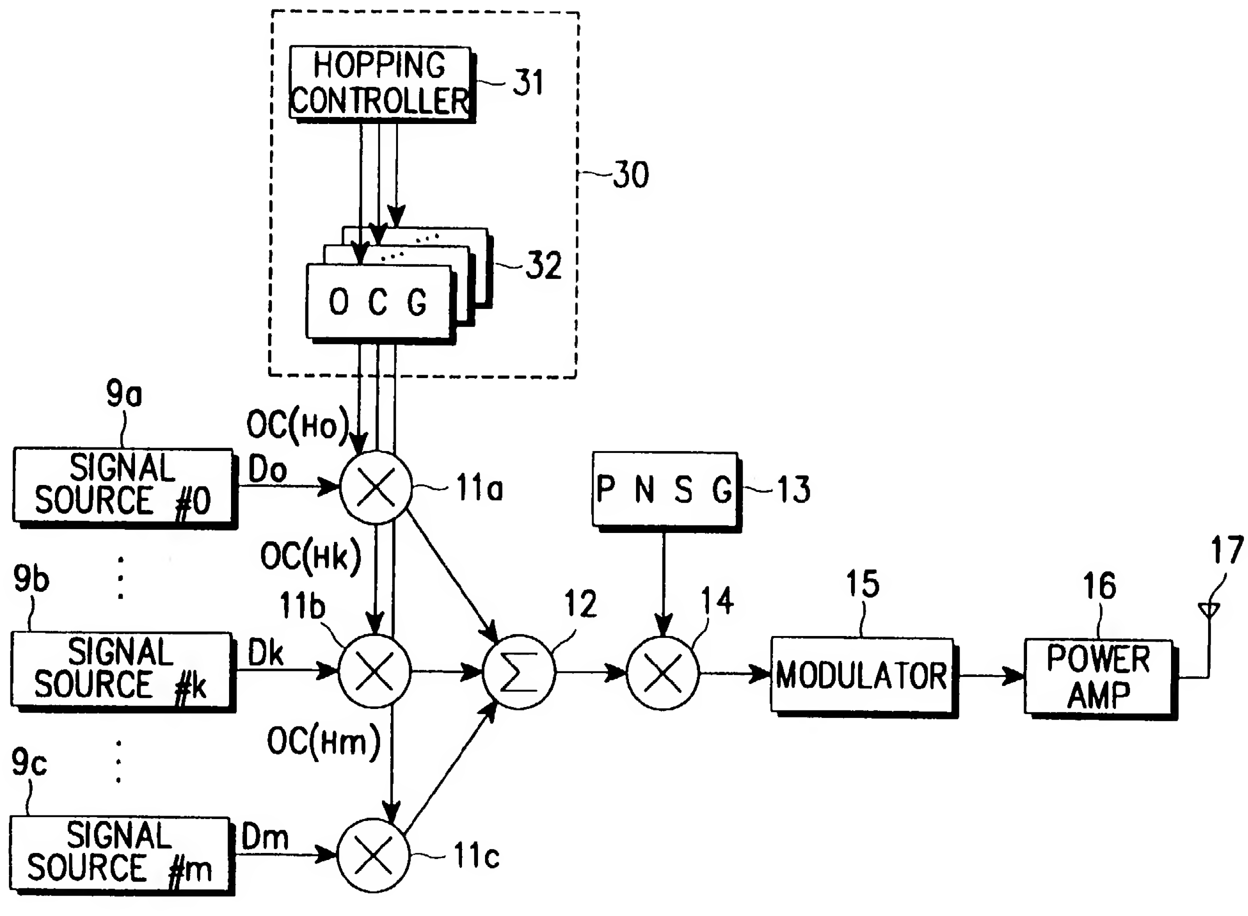

HOPPING CONTROLLER
31
30
32
O C G
9a
OC(Ho)
SIGNAL SOURCE #0
Do
11a
P N S G
13
OC(Hk)
9b
11b
12
14
15
16
17
SIGNAL SOURCE #k
Dk
MODULATOR
POWER AMP
OC(Hm)
9c
SIGNAL SOURCE #m
Dm
11c

FIG. 2A

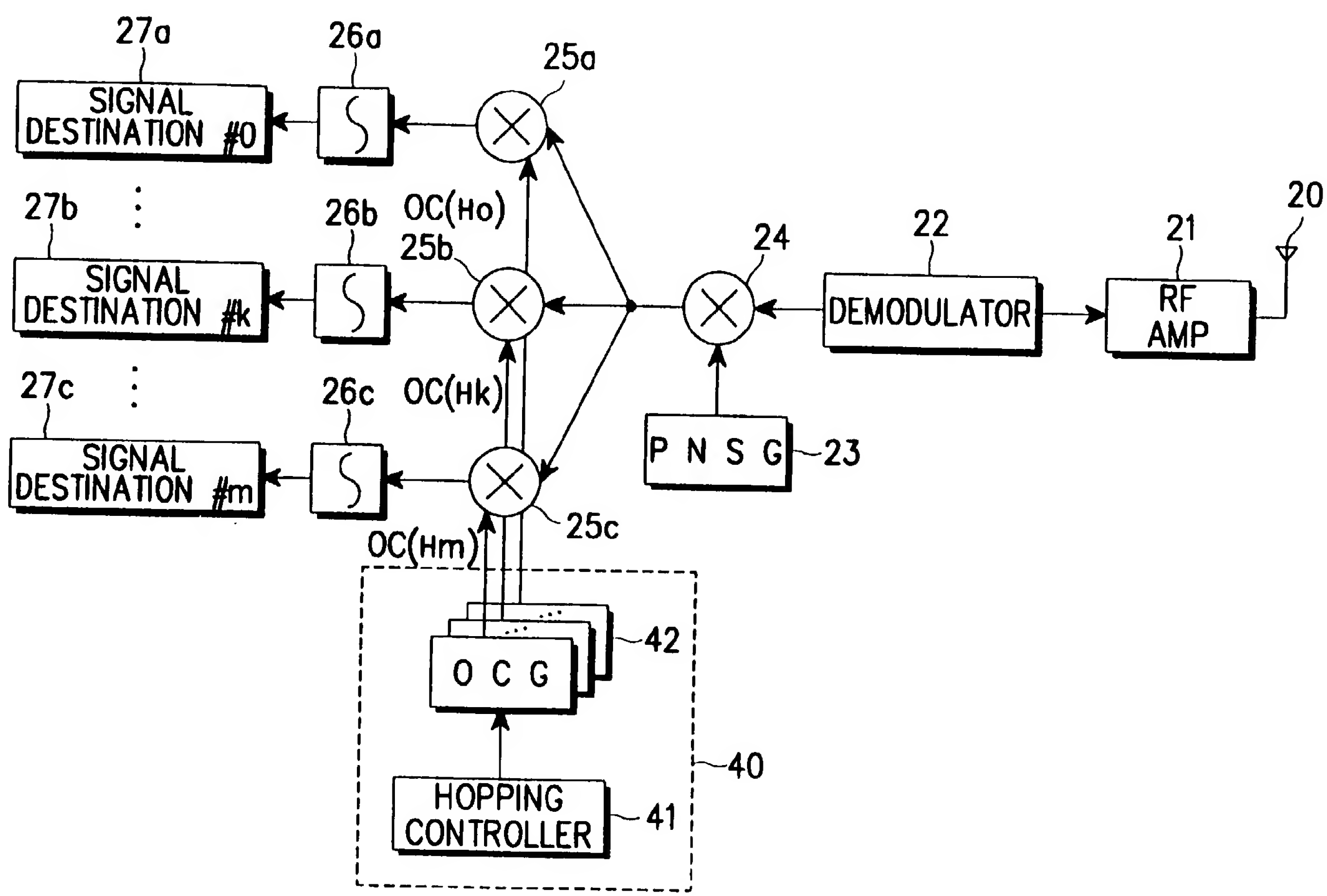

20
21
RF
AMP
22
DEMODULATOR
24
P N S G
23
25a
25b
25c
OC(Ho)
OC(Hk)
OC(Hm)
26a
26b
26c
27a
SIGNAL
DESTINATION #0
27b
SIGNAL
DESTINATION #k
27c
SIGNAL
DESTINATION #m
O C G
42
HOPPING
CONTROLLER
41
40

FIG. 2B

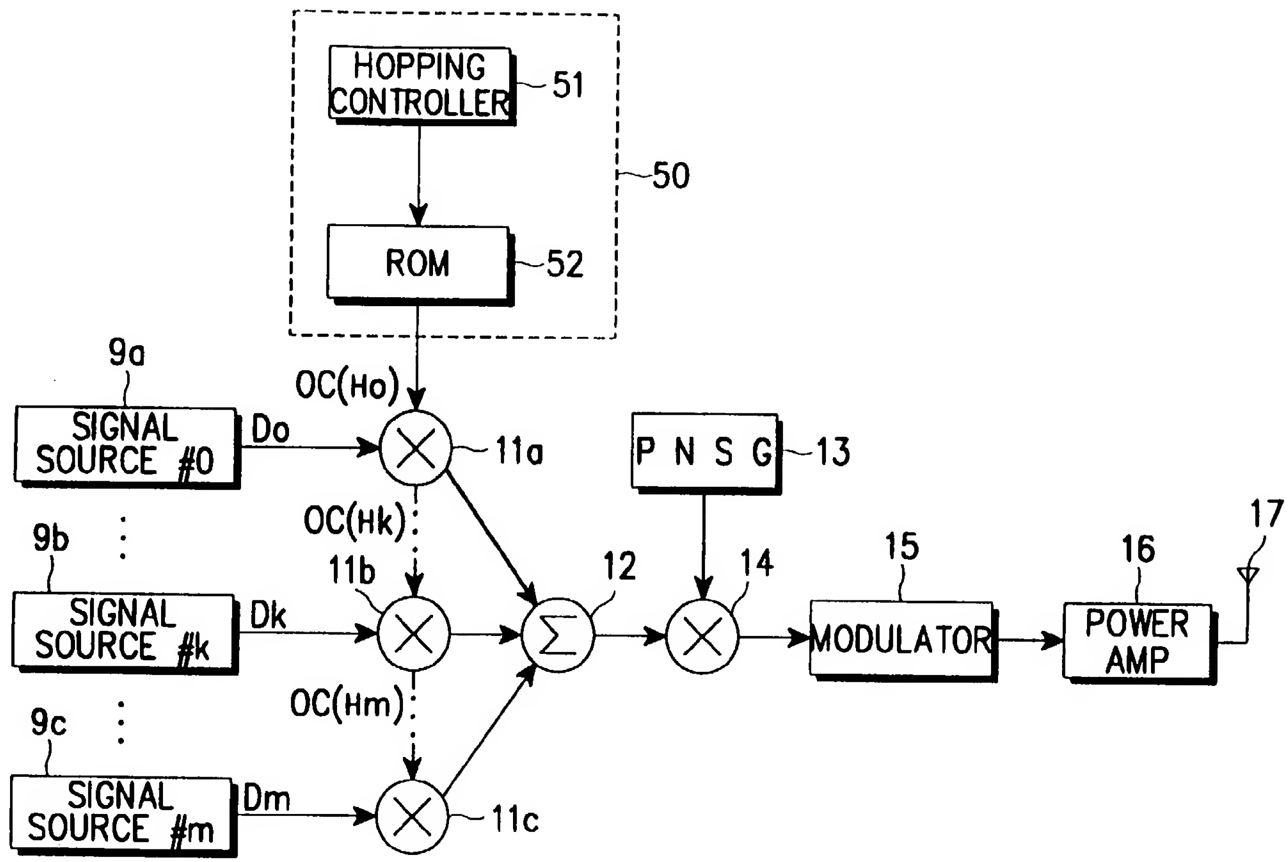

HOPPING CONTROLLER
51
50
ROM
52
9a
OC(Ho)
SIGNAL SOURCE #0
Do
11a
PNSG
13
9b
OC(Hk)
11b
12
14
15
16
17
SIGNAL SOURCE #k
Dk
MODULATOR
POWER AMP
9c
OC(Hm)
SIGNAL SOURCE #m
Dm
11c

FIG. 3A

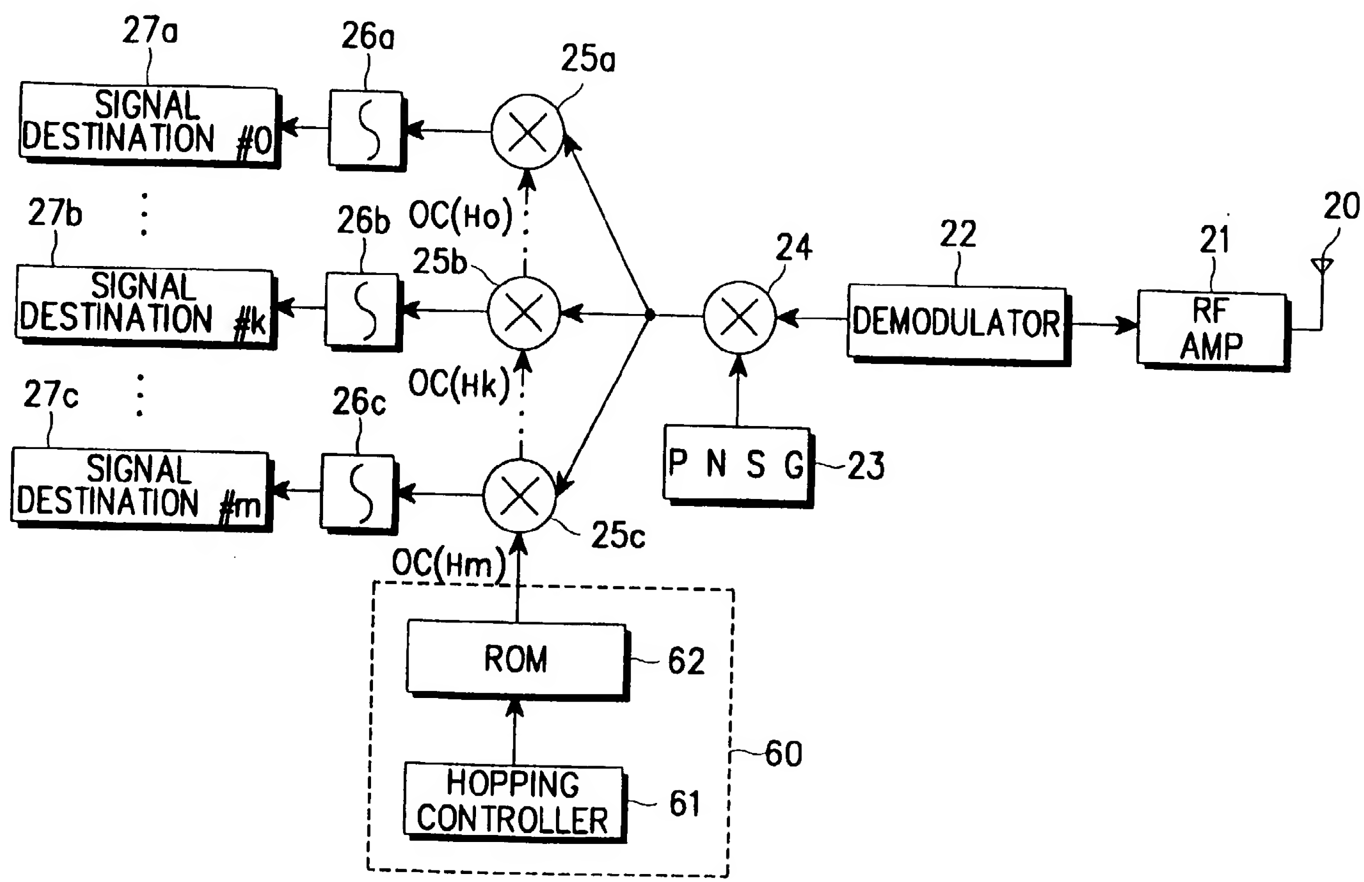

27a
SIGNAL DESTINATION #0
27b
SIGNAL DESTINATION #k
27c
SIGNAL DESTINATION #m
26a
26b
26c
25a
25b
25c
OC(Ho)
OC(Hk)
OC(Hm)
24
PNSG
23
22
DEMODULATOR
21
RF AMP
20
ROM
62
HOPPING CONTROLLER
61
60

FIG. 3B

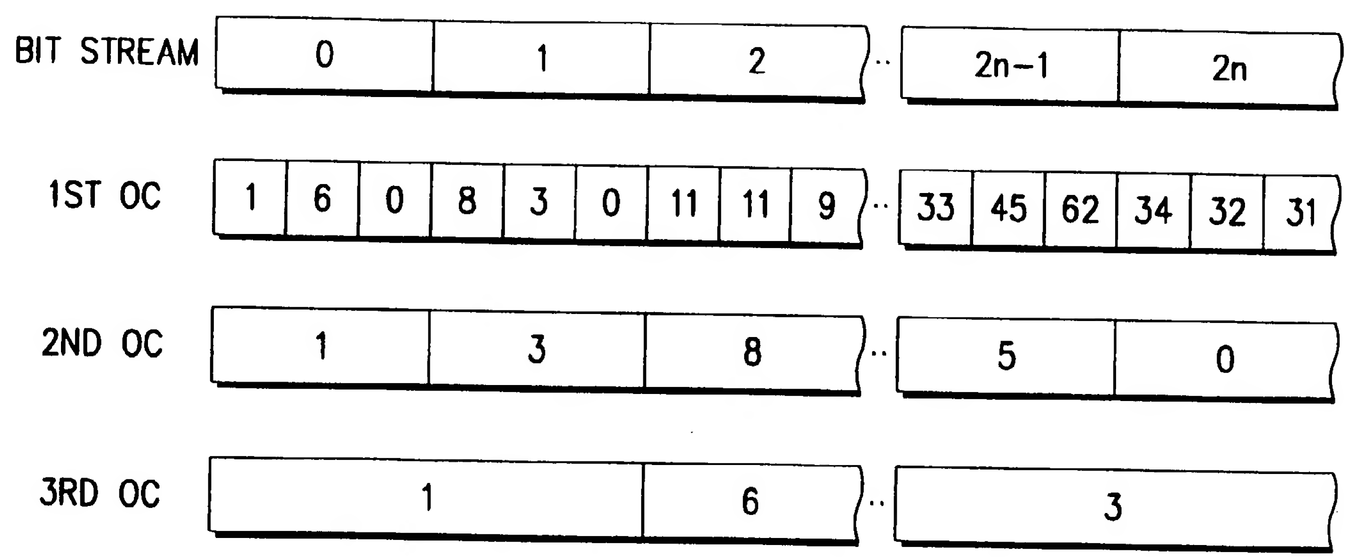

BIT STREAM
0
1
2
2n−1
2n
1ST OC
1
6
0
8
3
0
11
11
9
33
45
62
34
32
31
2ND OC
1
3
8
5
0
3RD OC
1
6
3

FIG. 4

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DIGITAL COMMUNICATION SYSTEM AND METHOD

The present invention relates to a digital communication system and method, preferably a CDMA (Code Division Multiple Access) communication system, and more particularly to an orthogonal code hopping multiple access (OCHMA) communication system which divides channels according to the hopping patterns of the orthogonal codes.

Figures 1A and 1B are diagrams illustrating the construction of a convention CDMA communication system using orthogonal codes. Figure 1A shows a transmitter and figure 1B shows a receiver. The orthogonal code may be, for example, a Walsh code, a Hadamard code or Gold code.

Referring to figure 1A, an orthogonal code generator (OCG) 10 generates orthogonal codes OC(0)-OC(m) for the respective digital signals D0-Dm output from signal sources 9a-9c. Mixers 11a-11c mix the digital signals D0-Dm with the corresponding orthogonal codes OC(0)-OC(m), and a summer 12 sums the mixed signals output from the mixers 11a-11c. A pseudo-noise sequence generator (PNSG) 13 generates a pseudo-noise sequence (PNS) or a pseudo-random sequence (PRS). A mixer (or multiplier) 14 multiplies an output signal of the summer 12 by the PNS and a modulator 15 modulates an output signal of the mixer 14 into a RF (Radio Frequency) signal. A power amplifier 16 amplifies the RF signal and radiates the amplified RF signal through an antenna 17.

Referring to Figure 1B, an RF amplifier 21 amplifies the RF signal received via an antenna 20. A demodulator 22 demodulates the RF signal output from the RF amplifier 21 in sync with a sync signal transmitted from the transmitter of Figure 1A. A mixer (or multiplier) 24 multiplies the demodulated signal output from the demodulator 22 by the PNS generated from an PNSG 23. An orthogonal code generator 28 generates orthogonal codes OC(0)-OC(m) identical to those in the transmitter. Mixers (or multipliers) 25a-25c multiply the output signal of the mixer 24 by corresponding orthogonal

codes OC(0)-OC(m). Integrators 26a-26c integrate the output signals of the mixers 25a-25c to restore the original digital signals D0-Dm and transfer the restored digital signal destinations 27a-27c.

As appreciated from the foregoing, in order to divide the channels, the conventional CDMA communication system allocates the unique orthogonal codes belonging to a specified set of the orthogonal codes to the respective channels and repeatedly multiplies the transmission digital signals by the allocated orthogonal codes. That is, the transmitter of Figure 1A repeatedly multiplies the allotted orthogonal codes for a bit duration of the digital signal to be transmitted, to spread the digital signal so that the spread digital signal may have wider spectrum than the original digital signal. In addition, the transmitter multiplies the transmission signals by the PNS to scramble the transmission signals so that the other terminals may not restore the scrambled transmission signals. The receiver of FIG 1B executes a reverse process of the transmitter. The receiver generates the PNS identical to that used in the transmitter and multiplies the received RF signal by the PNS. In addition, the receiver multiplies the multiplied RF signal by the orthogonal codes identical to those used in the transmitter, repeatedly, and integrates the signals for the bit duration of the digital transmission signal, to restore the original digital signals.

As apparent from the foregoing description, in the case where the digital signals have not been encrypted previously, the conventional CDMA communication system should multiply the digital signals by the PNS agreed between the transmitter and the receiver so as to encrypt the digital signals.

It is an object of the present invention to at least mitigate the problems of the prior art.

Accordingly, a first aspect of the present invention

provides a transmitter for digital communication system, the transmitter comprising a first hopping orthogonal code generator for generating orthogonal codes according to a hopping pattern; a plurality of mixers, each connected to the first hopping orthogonal code generator for multiplying digital signals by the orthogonal codes to produce orthogonally encoded digital signals; means for transmitting an output signal comprising the orthogonally encoded digital signals.

Preferably, a transmitter is provided wherein first hopping orthogonal code generator comprises: an orthogonal code generator for generating the orthogonal codes according to the hopping pattern; and a hopping controller connected to orthogonal code generator for generating hopping pattern.

A compromise may have to be reached between the speed of generation of an orthogonal code and the data rate of the data to be encoded.

Accordingly, an embodiment provides a transmitter wherein the first hopping orthogonal code generator comprises: a memory for storing the orthogonal codes for output according to the hopping pattern; and a hopping controller for generating the hopping pattern and outputting the hopping pattern to the memory.

By accessing pre-calculated orthogonal codes and storing those calculated codes in memory the speed with which such a code for use in encryption can be obtained is improved.

In a preferred embodiment there is provided a transmitter wherein the means for transmitting the output signal comprising the orthogonally encoded digital signals comprises: a summer connected to outputs of the mixers for summing the orthogonally encoded digital signals output from the mixers to produce a summer output signal; a modulator for modulating the summer output signal; an antenna; and a power

amplifier for amplifying an output signal of the modulator and radiating the amplified signal through the antenna.

In an encryption system, the more complex or varied the codes used for encryption, the greater the security of the encrypted data.

Therefore, an embodiment provides a transmitter wherein the duration of a code symbol of an orthogonal code used to orthogonally encode the digital signals varies as between orthogonal codes in relation to a data unit of a digital signal.

A second aspect of the present invention provides a receiver for a digital communication system, the receiver comprising means for receiving an output signal comprising orthogonally encoded digital signals; a second hopping orthogonal code generator for generating orthogonal codes according to a hopping pattern identical to that of a corresponding transmitter; a plurality of mixers for multiplying an output signal of the demodulator by the corresponding orthogonal codes; and a plurality of integrators for integrating output signals of the mixers to restore the digital signals.

Preferably, an embodiment provides a receiver wherein second hopping orthogonal code generator comprises: an orthogonal code generator for generating the orthogonal codes according to the hopping pattern; and a hopping controller connected to orthogonal code generator for generating hopping pattern.

A third aspect of the present invention provides a digital communication system, preferably a CDMA communication system which uses orthogonal codes, comprising a transmitter and a receiver.

A further aspect provides a transmitter for digital

communication system, the transmitter comprising a first hopping orthogonal code generator for generating orthogonal codes; a plurality of mixers, each connected to the first hopping orthogonal code generator for multiplying digital signals by the orthogonal codes to produce orthogonally encoded digital signals; means for transmitting an output signal comprising the orthogonally encoded digital signals; wherein the duration of a code symbol of the orthogonal codes used to orthogonally encode the digital signals varies as between orthogonal codes in relation to a data unit of a digital signal.

Advantageously, by varying the length of the orthogonal codes, preferably the code symbols, a function of encryption/decryption can be realised.

A still further aspect of the present invention provides a receiver for a digital communication system, the receiver comprising means for receiving an output signal comprising orthogonally encoded digital signals; a second hopping orthogonal code generator for generating orthogonal codes identical to that of a compatible transmitter; a plurality of mixers for multiplying an output signal of the demodulator by the corresponding orthogonal codes; and a plurality of integrators for integrating output signals of the mixers to restore the digital signals; wherein the duration of a code symbol of the at least one orthogonal code used to orthogonally encode the digital signals varies as between orthogonal codes in relation to a data unit of a digital signal.

Preferably, wherein the orthogonal codes are generated according to a selectable hopping pattern.

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figures 1A and 1B are diagrams showing the construction of a conventional CDMA communication system using orthogonal codes;

Figures 2A and 2B are diagrams showing the construction of an orthogonal code hopping multiple access communication system according to an embodiment of the present invention;

Figures 3A and 3B are diagrams showing the construction of an orthogonal code hopping multiple access communication system according to another embodiment of the present invention; and

Figure 4 is a timing diagram showing the hopping patterns of the orthogonal codes according to an embodiment of the present invention.

Figures 2A and 2B are diagrams showing the construction of an orthogonal code hopping multiple access (OCHMA) communication system according to an embodiment of the present invention, figure 2A shows a transmitter and figure 2B shows a receiver.

Referring now to figure 2A, the orthogonal code lopping multiple access system comprise a hopping orthogonal code generator 30 for generating orthogonal codes according to a hopping pattern. The generator 30 includes a hopping controller 31 for controlling the hopping pattern of the orthogonal codes and an OCG 32 for generating the orthogonal codes according to the hopping pattern under the control of the hopping controller 31. Mixers 11a-11c mix the digital signals D0-Dm output from the signal sources 9a-9c with the corresponding unique orthogonal codes OC(H0)-OC(Hm) generated according to a specified hopping pattern, and a summer 12 sums the digital output signals of the mixers 11a-11c. A PNSG 13 generates the PNS and a mixer (or multiplier) 14 multiplies the output signal of the summer 12 by the PNS. A demodulator 15 demodulates an output signal of the mixer 14 into the RF signal, and a power amplifier 16 amplifies the RF signal and radiates it through an antenna 17.

Referring to figure 2B, an RF amplifier 21 amplifies the RF signal received from the transmitter via an antenna 20. A demodulator 22 demodulates the amplified RF signal output from the RF amplifier 21. A PNSG 23 generates a PNS which is identical to that used in the transmitter and a mixer 24 multiplies the demodulated signal by the PNS. A hopping orthogonal code generator 40, consisting of an orthogonal code generator 42 and a hopping controller 41, generates orthogonal codes OC(H0)-OC(Hm) according to a hopping pattern which is identical to that used in the transmitter. Mixers (or multipliers) 25a-25c multiply the signal output from the mixer 24 by the corresponding orthogonal codes OC(H0)-OC(Hm), respectively. The integrators 26a-26c integrate the output signals of the mixers 25a-25c to restore the digital signals D0-Dm and transfer them to the signal destinations 27a-27c.

Figures 3A and 3B are diagrams illustrating the construction of an OCHMA communication system according to another embodiment. It should be noted that figures 3A and 3B are identical to the construction of figures 2A and 2B, except for the construction of the orthogonal code hopping generates 50 and 60. As illustrated, the orthogonal code hopping generator 50 consists of a hopping controller 51 for controlling the hopping patterns of the orthogonal codes and a ROM (Read Only Memory) 52 for outputting the orthogonal codes stored therein according to the hopping patterns dictated by the hopping controller 51. Similarly, the orthogonal code hopping generator 60 consists of a hopping controller 61 for controlling the hopping pattern of the orthogonal code and a ROM 62 for outputting the orthogonal codes stored therein under the control of the hopping controller 61.

Figure 4 is a timing diagram showing the hopping patterns of the orthogonal codes according to an embodiment of the present invention. As illustrated, a first orthogonal code (OC) hops three times for every bit duration of the bit stream. Therefore, the orthogonal code may be relatively

shorter as compared to the bit duration. A second orthogonal code has a hopping time which is identical to the bit duration. A third orthogonal code hops every two bit duration so that the hopping time is n times the bit duration (where n is an integer). In the illustrative example n is two.

As described above, the OCHMA communication system of the invention can uniformly distribute the power density at a certain frequency band as compared with the conventional CDMA communication system, even without multiplying the pseudo-noise sequence, and only the receiver perceiving the hopping pattern can restore the digital signals. Thus, the communication system has the encryption function. Further, by multiplying the digital signals by the pseudo-noise sequence, the present invention can reinforce the encryption function and secure a more uniform, that is disposed, power spectral density.

CLAIMS

1. A transmitter for digital communication system, the transmitter comprising

a first hopping orthogonal code generator for generating orthogonal codes according to a hopping pattern;

a plurality of mixers, each connected to the first hopping orthogonal code generator for multiplying digital signals by the orthogonal codes to produce orthogonally encoded digital signals;

means for transmitting an output signal comprising the orthogonally encoded digital signals.

2. A transmitter as claimed in claim 1, wherein first hopping orthogonal code generator comprises:

an orthogonal code generator for generating the orthogonal codes according to the hopping pattern; and

a hopping controller connected to orthogonal code generator for generating hopping pattern.

3. A transmitter as claimed in claim 1, wherein the first hopping orthogonal code generator comprises:

a memory for storing the orthogonal codes for output according to the hopping pattern; and

a hopping controller for generating the hopping pattern and outputting the hopping pattern to the memory.

4. A transmitter as claimed in any preceding claim, wherein the means for transmitting the output signal comprising the orthogonally encoded digital signals comprises:

a summer connected to outputs of the mixers for summing the orthogonally encoded digital signals output from the mixers to produce a summer output signal;

a modulator for modulating the summer output signal;

an antenna; and

a power amplifier for amplifying an output signal of the modulator and radiating the amplified signal through the

antenna.

5. A transmitter as claimed in any preceding claim, wherein the duration of a code symbol of an orthogonal code used to orthogonally encode the digital signals varies as between orthogonal codes in relation to a data unit of a digital signal.

6. A transmitter as claimed in any preceding claim, wherein the hopping pattern varies in a predeterminable manner.

7. A transmitter substantially as described herein with reference to and/or as illustrated in figure 2A, 3A and 4.

8. A receiver for a digital communication system, the receiver comprising

means for receiving an output signal comprising orthogonally encoded digital signals;

a second hopping orthogonal code generator for generating orthogonal codes according to a hopping pattern identical to that of a compatible transmitter;

a plurality of mixers for multiplying an output signal of the demodulator by the corresponding orthogonal codes; and

a plurality of integrators for integrating output signals of the mixers to restore the digital signals.

9. A receiver as claimed in claim 8, wherein second hopping orthogonal code generator comprises:

an orthogonal code generator for generating the orthogonal codes according to the hopping pattern; and

a hopping controller connected to orthogonal code generator for generating hopping pattern.

10. A receiver as claimed in claim 8, wherein the second hopping orthogonal code generator comprises:

a memory for storing the orthogonal codes for output according to the hopping pattern; and

a hopping controller for generating the hopping pattern

and outputting the hopping pattern to the memory.

11. A receiver as claimed in any of claims 8 to 10, wherein the means for receiving the output signal comprising orthogonally encoded digital signals comprises

an antenna for receiving a receive signal comprising the orthogonally encoded digital signals;

a radio frequency (RF) amplifier for amplifying the receive signal to produce an amplified receive signal; and

a demodulator for demodulating the amplified receive signal.

12. A receiver as claimed in any of claims 8 to 12, wherein the duration of a code symbol of an orthogonal code used to orthogonally encode the digital signals varies as between orthogonal codes in relation to a data unit of a digital signal.

13. A receiver as claimed in any of claims 8 to 11, wherein the hopping pattern varies in a predeterminable manner.

14. A receiver substantially as described herein with reference to and/or as illustrated in figures 2B, 3B and 4.

15. A digital communication system comprises a transmitter as claimed in any of claims 1 to 7 and a receiver as claimed in any of claims 8 to 14.

16. A digital communication system substantially as described herein with reference to and/or as illustrated in figures 2, 3 and 4.

17. A transmitter for digital communication system, the transmitter comprising

a first hopping orthogonal code generator for generating orthogonal codes;

a plurality of mixers, each connected to the first hopping orthogonal code generator for multiplying digital

signals by the orthogonal codes to produce orthogonally encoded digital signals;

means for transmitting an output signal comprising the orthogonally encoded digital signals;

wherein the duration of a code symbol of the orthogonal codes used to orthogonally encode the digital signals varies as between orthogonal codes in relation to a data unit of a digital signal.

18. A receiver for a digital communication system, the receiver comprising

means for receiving an output signal comprising orthogonally encoded digital signals;

a second hopping orthogonal code generator for generating orthogonal codes identical to that of a compatible transmitter;

a plurality of mixers for multiplying an output signal of the demodulator by the corresponding orthogonal codes; and

a plurality of integrators for integrating output signals of the mixers to restore the digital signals;

wherein the duration of a code symbol of the at least one orthogonal code used to orthogonally encode the digital signals varies as between orthogonal codes in relation to a data unit of a digital signal.

19. A transmitter as claimed in claim 17 or a receiver as claimed in claim 18, wherein the orthogonal codes are generated according to a selectable hopping pattern.

20. A digital communication system comprising a transmitter as claimed in either of claims 17 or 19 and a receiver as claimed in either of claims 17 or 19.

Application No: GB 9816682.0
Claims searched: 1 to 20

Examiner: Ken Long
Date of search: 3 March 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H4P (PDCSL)
H4M (MA)

Int Cl (Ed.6): H04L (9/18, 9/20, 9/22 & 9/26)
H04J (13/00, 13/02 & 13/04)
H04K 1/00

Other: ONLINE : WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2282300 A	NORTHERN TELECOM (pages 2 and 3)	None
A	GB 2278260 A	MOTOROLA (page 5 lines 20-27 and page 9 lines 5-8)	None

X Document indicating lack of novelty or inventive step	A Document indicating technological background and/or state of the art.
Y Document indicating lack of inventive step if combined with one or more other documents of same category.	P Document published on or after the declared priority date but before the filing date of this invention.
& Member of the same patent family	E Patent document published on or after, but with priority date earlier than, the filing date of this application.